A Slick Study! Natural Oil Seeps and Chlorophyll

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Article

D'Souza, N.A., Subramaniam, A., Juhl, A.R., Hafez, M., Chekalyuk, A., Phan, S., Yan, B., MacDonald, I.R., Weber, S.C. and Montoya, J.P., (2016), Elevated surface chlorophyll associated with natural oil seeps in the Gulf of Mexico, Nature Geoscience (Advanced Online Publication), 1-4, DOI: 10.1038/NGEO2631

Background

What are Oil Seeps?

Oil seeps (also called petroleum or hydrocarbon seeps) are naturally occurring places on land and along the seafloor where oil, or other forms of petroleum, escapes from deep reservoirs (Fig 1). Oil or gas migrates through pore spaces in sediments or fractures in rocks, and under certain conditions is squeezed out through organized vent systems. Oil seeps occurring along the seafloor make up 47% of the oil that is discharged to the world's oceans. In the Gulf of Mexico alone, between 1 and 5 million barrels (80,000 – 200,000 tonnes) of oil naturally seep from the seafloor each year! (source: Oil in the Sea III, National Academies Press Open Book, p. 70). Since oil is less dense than seawater, oil buoyantly rises in a plume to the ocean's surface.

Figure 1. The Yanar Dag fire, an inextinguishable gas seep along roadside in Azerbaijan (top left, source: Wikicommons). An oil seep in north Slovakia (top right, source: Wikicommons). A gas bubble forming from an oil seep in the Gulf of Mexico (bottom, source: NOAA Photo Library).

The impacts of oil seeps to seafloor (benthic) biology and ecosystems have been well studied, with perhaps counterintuitive results: natural oil seeps appear to support benthic productivity. In this study, D'Souza and colleagues look to answer questions about the impacts of oil seeps to the biology of the waters directly above, including at the ocean's surface.

Methods

The researchers focused their study in the Gulf of Mexico, a region with numerous naturally occurring oil seeps (and of course a region devastated by the BP Deepwater Horizon Oil spill in April 2010). Previous studies have indicated that oil seeps in the Gulf of Mexico tend to reach the surface almost directly above the vent. To better understand how oil seeps effect the biology at the ocean's surface, the researchers measured chlorophyll concentrations above natural oil seeps and in sites that are not impacted by oil seeps. Chlorophyll is the chemical that

photosynthetic organisms (plants on land and phytoplankton in the ocean) use to produce food from solar energy, carbon dioxide and water, and thus can serve as an indicator of ecosystem productivity.

How did the researchers measure chlorophyll concentrations?

1. Direct measurements of chlorophyll concentrations were made using a device called a chlorophyll fluorometer, paired with a conductivity-temperature-depth (CTD) profiling system (Fig 2). This allowed the researchers to compare chlorophyll concentrations and temperatures at different depths above oil seeps and at background sites not influenced by oil seeps.
2. Shipboard measurements of surface chlorophyll concentrations above oil seeps and at background sites not influenced by oil seeps.
3. Satellite measurements of oil slicks (the surface expression of oil seeps) and chlorophyll concentrations (Fig 2). The researchers identified a site, referred to as “Alpha”, as a 10×10 km area that was most covered by oil slicks between 1997 and 2007. They also identified several background sites that were not impacted by oil slicks over the same decade. Following each oil slick, changes in chlorophyll concentrations were observed for 8 days to quantify the effects of oil slicks on surface chlorophyll concentrations.

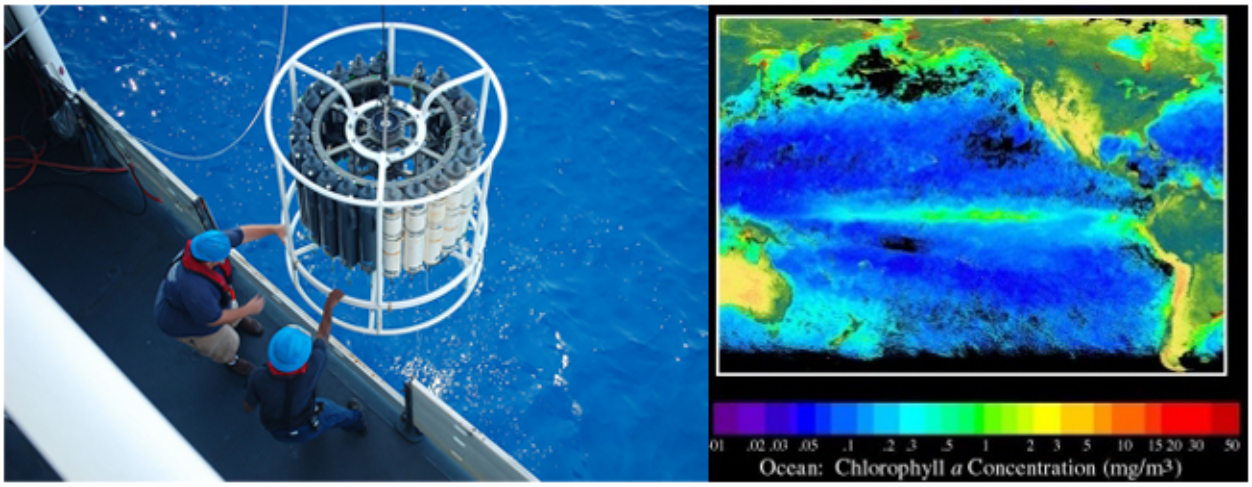

Figure 2. A CTD rosette system being deployed at sea (left, source: NOAA Photo Library). A satellite derived chlorophyll concentration map (right, source: NOAA Photo Library).

Results

So what did the researchers find?

In all three observational methods, researchers found that oil seeps significantly increase chlorophyll concentrations near or at the ocean’s surface. In fact, maximum chlorophyll concentrations at oil seep sites were more than twice that of background sites and occurred at significantly shallower depths. Observations from the historical satellite data also agree:

Changes in chlorophyll concentrations at site “Alpha” following the presence of an oil slick far exceeded that of the background sites.

This study demonstrates that there is excellent correlation between oil seeps and surface chlorophyll concentrations, but what is the mechanism? Temperature profiles also revealed significantly colder water directly above oil seeps. This key finding led the researchers to hypothesize that rising, buoyant plumes of oil drag cold, deep and nutrient rich water towards the surface, a process called upwelling. In this hypothesis, upwelling describes the causation between oil seeps and increasing chlorophyll concentrations at the surface. Phytoplankton rely on the nutrients upwelled above oil seeps, allowing phytoplankton (chlorophyll) to increase in concentration.

The researchers were quick to note that the upwelling mechanism may be oversimplified, and there very well could be complex ecosystem dynamics that remain undiscovered, warranting further study.

Significance

Oil in the ocean is typically thought of as ecologically detrimental and caused by human activities. However, oil seeps are completely natural and serve as significant inputs of oil to the ocean that support photosynthetic phytoplankton. In many fields of science, it is critical to understand the functions of a natural system such that perturbations (e.g. an oil spill) can be properly assessed. This study provides new insight of how oil seeps impact chlorophyll concentrations at the ocean’s surface.

Did you expect that oil could play a key role in marine ecosystems?